# Design of a Fractal-Based Circularly Polarized UHF RFID Reader Antenna

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***Abstract*— The coplanar waveguide (CPW) fractal antennas have been given importance in recent days at lower frequencies by considering its advantage of obtaining wider bandwidth. Presently, RF domain is mainly concentrating on design of circularly polarized (CP) antennas for RFID applications as the reader can access the tag information regardless of its polarization. This mainly improves the reading capabilities of RFID reader, which is a major design constraint in whole RFID domain. This project presents the design of a coplanar waveguide (CPW) circularly polarized antenna for the central frequency 900 MHz, it comes in handy for radio frequency identification(RFID) short-range reading applications within the band of 902–928 MHz where the axial ratio of proposed antenna model is less than 3 dB. The proposed design has an axial-ratio bandwidth of 36 MHz (4%) and impedance bandwidth of 256 MHz (28.5%). The proposed design includes monopole a CPW structure concept to provide larger bandwidth at lower frequency 900 MHz, which comes to be an enormous increment typically from 4% to 5% for a general square patch (FR-4) substrate antenna to greater than 20% for CPW monopole structure. It includes fractal antenna concepts to achieve compactness as well as circular polarization.**

***Keywords*— circular polarization, coplanar waveguides (CPWs), fractal antennas, radio frequency Identification (RFID), ultra-high frequency (UHF).**

## I. INTRODUCTION

Radio frequency identification (RFID) is a wireless data access technology that uses two components for information exchange, it relies on tag for product information transmission and reader for data reception. The RFID system consists of two main components tags and reader. The reader always interrogates the tags which is equipped with antenna, transceiver and processor (along with software). The tags (transponder) are powered by and read at short distance ranges via magnetic field such as electromagnetic induction. The tags may use an on-board power source such as a battery, which is called active tag. Another type tag where energy is collected from the interrogating EM field, act as a passive transmitter and receiver to emit UHF (3MHZ to 3GHZ) radio wave is called a passive tag There are many types of RFID systems used in different applications and settings which have different power source, operating frequency and functionalities. These properties and dictatorial restrictions of a particular RFID system will determine its physical specifications, manufacturing expenses and performance. RFIDs are operated in low-frequency (LF), high-frequency (HF), and ultra-high frequency (UHF) and microwave frequency bands, respectively, in which UHF band is very popular in RFID domain for reader construction because of its long read range (1–10 m), and it is mostly used in applications like pallet tracking, carton tracking, electronic toll collection, and parking lot access [1]. Globally, every nation has its own spectrum reserved for UHF RFID applications, like 840.5–844.5 and 920.5–924.5 MHz in China, 865–867 MHz in India, 902–928-MHz band in Argentina and America, 866–869 and 920–925 MHz in Singapore, and 952–955 MHz in Japan, and so on, so considering all these stated values, UHF RFID frequency ranges from 840 to 955 MHz (a fractional bandwidth of 12.75%) [2]. The basic operation principle of a CP antenna is to excite two orthogonal modes with equal strength ( Ex = Ey) but with opposite phase quadrature,To achieve circular polarization, there are several methods such as edge truncated patch antennas [3], dual-fed orthogonal-mode exciting antennas [4], slotted patch antennas [5], and CPW slotted patch antennas [6].

## II. ANTENNNA CONFIGURATION

Fig. 1(a) represents a general microstrip CPW monopole antenna,the main advantage of CPW configuration is that the signal and ground configurations can be achieved on the same plane, which reduces fabrication cost for UHF antenna designs.The absence of a ground plane in a CPW gives omnidirectional pattern, but directivity can be improved by using an additional ground plane. This idea is implemented and further improvised in this letter by using fractals to achieve circular polarization as well as bandwidth enhancement. Fractals are generally geometric iterative structures that can be used as radiating elements,thereby creating several resonant frequencies in the same antenna structure. The fundamental mode resonating frequency can be brought down by using fractals by increment of total electrical length, which nourishes the compactness issue in the antenna. The basic fractal structure may be a line, a surface, or even a volume. In particular, fractal geometry has been useful to design small, multiband, and high-directive antennas [10]–[12].There are multiple methods in practice to induce circular polarization in a patch antenna. This letter mainly emphasizes the concept of a first-order iterative fractal structure to create circular polarization. In Fig. 1(a), FR-4 (relative dielectric constant = 4.3) , thickness = 1.6 mm, loss tangent =0.025) is considered as substrate, and its overall dimension is 90 x 105 $mm^2$ . Fig. 1(b) indicates the general monopole antenna with ( λ/4) CPW feed and ground plane, from which two microstrip lines of length (λ/8 ) are projected out in the slant 45˚ plane, which mainly promotes to the initiation of axial ratio in the structure. Fig. 1(c) indicates the first iteration of the antenna with inverted L-structure of perimeter (3λ/16 ). The main motto of fractal usage in this letter is to increase the total perimeter of the antenna such that it resonates at the central frequency of 900 MHz. The two arms of the proposed structure always maintain diagonally opposite relation at every iteration phase, thereby generating CP in the antenna. A ground plane stub of length L= 30 mm with 3 mm width is projected out from the CPW ground plane to improve the axial ratio of the given structure along with proper impedance matching of 50 . The proposed structure generates right-hand circular polarization (RHCP), while its arms can be flipped to generate left-hand circular polarization (LHCP) consequently.

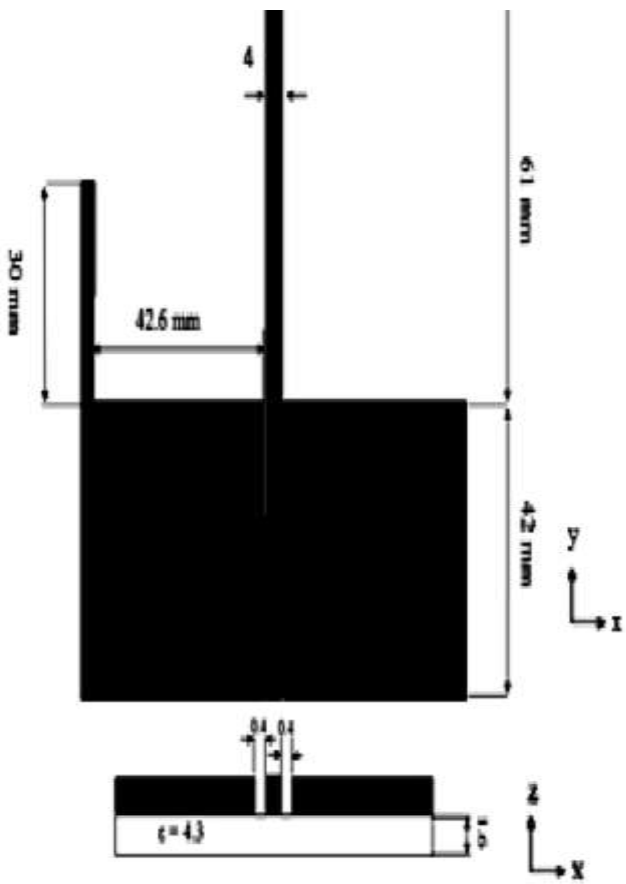

Fig. 1(a): CPW monopole antenna without the fractal structure

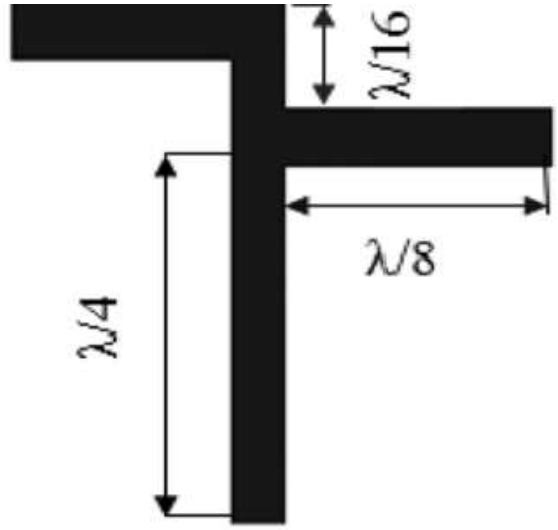

Fig. 1(b): Z-shaped monopole

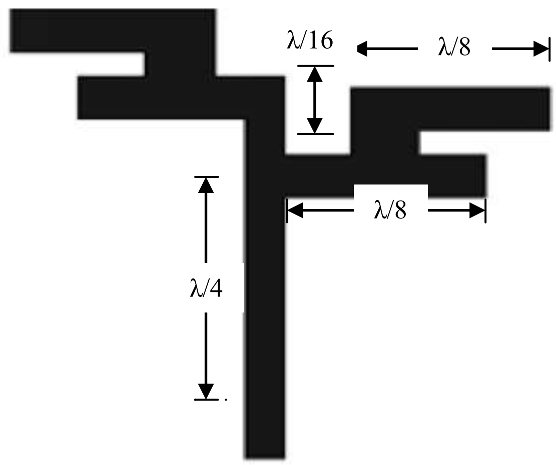

Fig. 1(c): Inverted L-Fractal,λ=160 mm at 900 Mhz

## III. SIMULATION AND RESULTS

Fig. 2(a) represents the VSWR versus the frequency characteristics of the general monopole CPW structure. The simulated and measured VSWR of general CPW structure have to be compared with the proposed structure. Fig. 2(b) represents the VSWR versus the frequency characteristics of the Z-shaped monopole. Fig. 2(c) represents the VSWR versus the frequency characteristics of the Inverted L-Fractal, λ=160 mm at 900 Mhz. From the graphs obtained from the three different structures it is evident that the VSWR value increases by increasing the no. of fractal structures at the central frequency of 900 Mhz. So, in this case the return losses in the antenna decreases it is calculated using the formula

Return loss = -20 log(VSWR-1/VSWR+1)

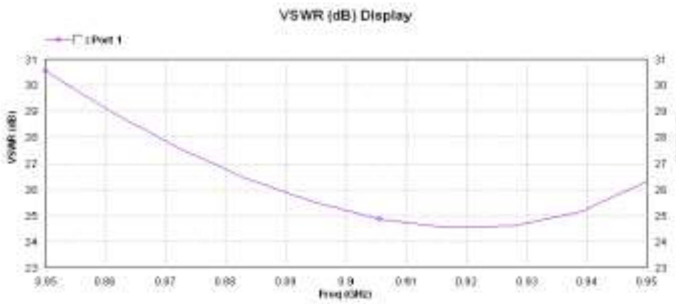


Fig. 2(a): VSWR vs Frequency characteristices of CPW monopole antenna without the fractal structure

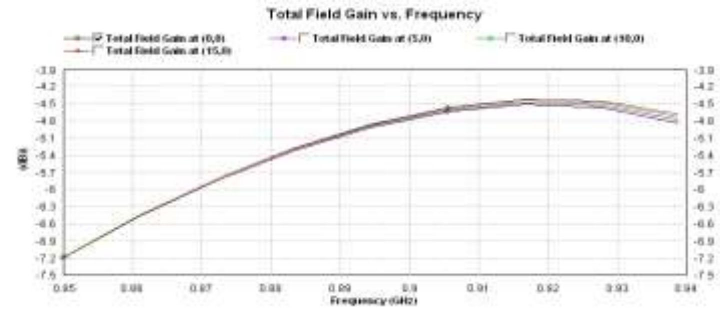


Fig. 3(a): Gain vs Frequency characteristices of CPW monopole antenna without the fractal structure

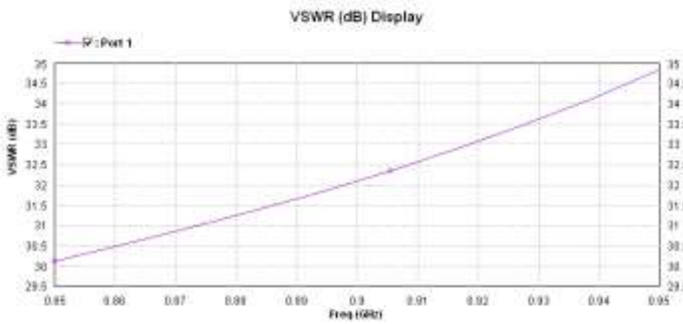


Fig. 2(b): VSWR vs Frequency characteristices of Z-shaped monopole

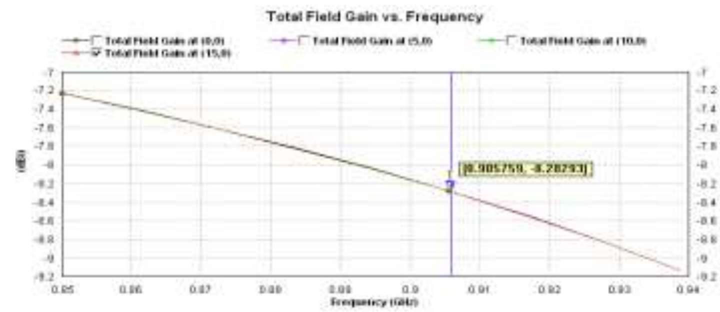


Fig. 3(b): Gain vs Frequency characteristices of Z-shaped monopole

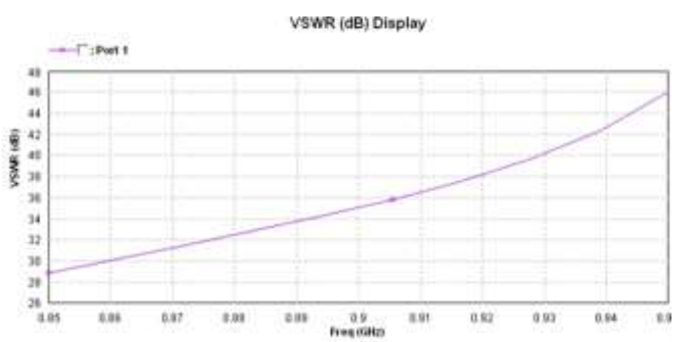


Fig. 2(c): VSWR vs Frequency characteristices of Inverted L-Fractal, λ=160 mm at 900 Mhz

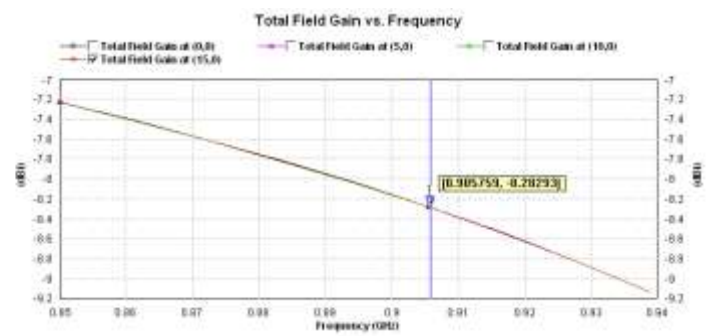


Fig. 3(c): Gain vs Frequency characteristices of Inverted L-Fractal, λ=160 mm at 900 Mhz

Fig. 3(a) represents the Gain versus the frequency characteristics of the general monopole CPW structure. The simulated and measured Gain of general CPW structure have to be compared with the proposed structure. Fig. 3(b) represents the Gain versus the frequency characteristics of the Z-shaped monopole. Fig. 3(c) represents the Gain versus the frequency characteristics of the Inverted L-Fractal, λ=160 mm at 900 Mhz. From the graphs obtained from the three different structures it is evident that the Gain of the antennas decreases by increasing the no. of fractal structures at the central frequency of 900 Mhz. From the gain and bandwidth relationship it can be proved that as the gain decreases the bandwidth of the antenna increases.

Fig. 4(a) represents the smith chart of the general monopole CPW structure. Fig. 4(b) represents the smith chart of the Z-shaped monopole. Fig. 4(c) represents the smith chart of the Inverted L-Fractal, λ=160 mm at 900 Mhz. These diagrams are evaluated to provide better impedance matching in the antennas. By using the smith chart impedances, reflection coefficients, noise figure of the different structures at the central frequency of 900Mhz can be obtained.

These parameters are obtained in order to determine how effective the antenna can be with and without the fractal structures. The proposed structure uses fractals to achieve circular polarization and CPW to achieve wider bandwidth. The size of the antenna is considerably small when compared to all other types of commercial antennas.

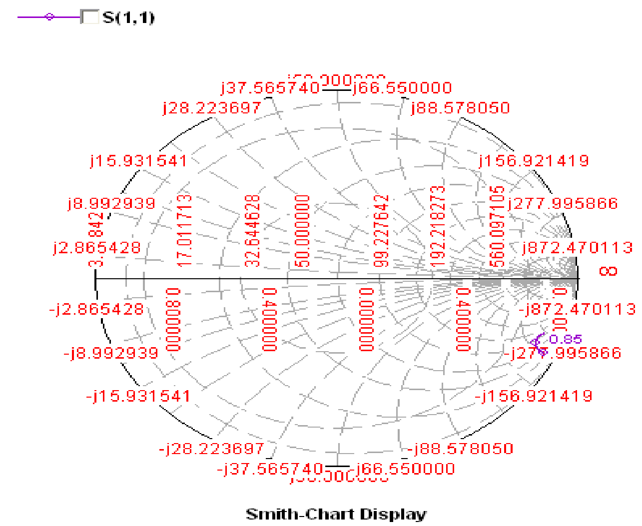


Fig. 4(a): Smith chart of CPW monopole antenna without the fractal structure

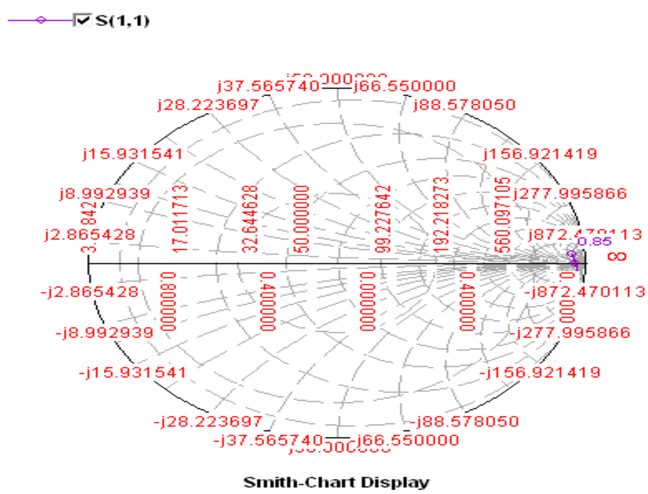


Fig. 4(b): Smith chart of Z-shaped monopole

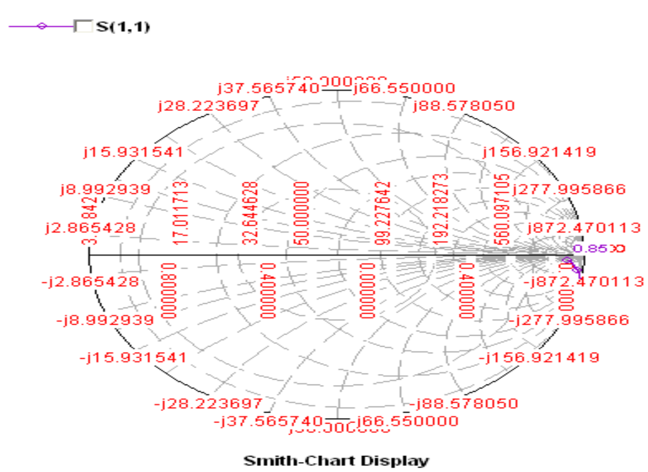


Fig. 4(c): Smith chart of Inverted L-Fractal, λ=160 mm at 900 Mhz

TABLE 1
GAIN AND VSWR AT 900 MHZ

| | | | |
|---|---|---|---|
| Gain | 4.63891 | -8.2903 | -10.0371 |
| VSWR | 24.8763 | 32.3465 | 35.8807 |

## IV. CONCLUSION

In this project ,we have designed the initial strutures of a fractal based circularly polarized uhf rfid reader antenna.the main benefit of this proposed reader is its compactnes and its additional advantage is circular polarization ( db) from 900 to 936 mhz (4%) with central frequency of 900 mhz. Because of the moderate gain and size , the proposed structure is precisely suitable for short-range rfid reading applications.


## ACKNOWLEDGEMENTS

I would like to thank God the almighty and also express my gratitude of thanks to Mrs. M.Revathi (Associative Professor of ECE department) who was a guiding support for the successful completion of this thesis, I, would also like to thank my parents who were a moral support in encouraging me throughout my work.


## REFERENCES


[1]. A.Parvathy, V. R. R. Gudivada, M. V. Reddy, and G. M. Chaitanya, "RFID based exam hall maintenance system", Int. J. Comput.Appl., vol.4, Special Issue on Artificial Intelligence Techniques—Novel Approaches & Practical Applications, pp. 31–37, 2011.

[2]. H. Barthel, "Regulatory status for RFID in the UHF spectrum," EPC Global, Brussels, Belgium, 2007 [On-line].Available:http://www.epcglobalinc.org/tech/req_reg/RFID_at_UHF_Regulations_20070504.pdf.

[3]. Z.N.Chen, X.Qing, and H.L.Chung," A universal UHF RFID reader antenna," IEEE Trans.Microw. Theory Tech., vol. 57, no. 5, pt. 2, pp. 1275–1282, May 2009.

[4]. Y.-F. Lin, H.-M. Chen, F.-H. Chu, and S.-C. Pan, "Bidirectional radiated circularly polarised square-ring antenna for portable RFID reader, "Electron. Lett., vol.44, no.24, pp.1383–1384,Nov.2008.

[5]. Nasimuddin, Z. N. Chen, and X. Qing, "Asymmetric-circular shaped slotted microstrip antennas for circular polarization and RFID applications,"IEEE Trans. Antennas Propag.,vol.58,no.12,pp.3821–3828, Dec. 2010.

[6]. J.-Y. Jan, C.-Y. Pan, K.-Y. Chiu, and H.-M. Chen, "Broadband CPW-fed circularly-polarized slot antenna with an open slot," IEEE Trans. Antennas Propag., vol.61, no.3, pp.1418–1422,Mar.2013.

[7]. B. Shrestha, A. Elsherbeni, and L. Ukkonen, "UHF RFID reader antenna for near-field and far-field operations," IEEE Antennas Wireless Propag. Lett., vol. 10, pp. 1274–1277, 2011.

[8]. M. V. Rusu and R. Baican, "Fractal antenna applica tions," [Online]. Available: http://cdn.intechopen.com/pdfs/10348/InTechFractal_antenna_applications.pdf

[9]. C. Varadhan, J. K. Pakkathillam, M. Kanagasabai, R. Sivasamy, R. Natarajan, and S. K. Palaniswamy, "Triband antenna structures for RFID systems deploying fractal geometry," IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 437–440, 2013.

[10]. J. Anguera, C. Puente, C. Borja, and J. Soler, "Fractal-shaped antennas: A review," in Wiley Encyclopedia of RF and Microwave Engineering. Hoboken, NJ, USA: Wiley, 2005, vol.2, pp.1620–1635.

[11]. D. H. Werner, R. L. Haupt, and P. L. Werner, "Fractal antenna engineering: The theory and design of fractal antenna arrays", IEEE Antennas Propag. Mag., vol.41, no.5, pp.37–58,Oct.1999.

[12]. J. Anguera, J. P. Daniel, C. Borja, J. Mumbrú, C. Puente, T. Leduc, N. Laeveren,and P. Van Roy, "Metallized foams for fractal-shaped microstrip antennas, "IEEE Antennas Propag. Mag., vol. 50, no.6, pp. 20–38, Dec. 2008

[13]. Laird Technologies,St. Louis,MO, USA, "Laird/ S9025PR,"2009[Online].Available:http://distiassets.s3.amazonaws .com/arcadianinc/files/datasheets/4122.pdf.

[14]. Impinj, Seattle, WA, USA, "IPJ-A0402-USA guard- wall ILT antenna datasheet" 2010 [Online]. Available: http://www.impinj.com/Documents/Reader_Antennas/ Guard wall_Reader_Antenna_Datasheet_(FCC).

[15]. Motorola Solutions, Inc., Schaumburg, IL, USA, "AN720 RFID antenna," 2013 [Online]. Available: http://www.motorola.com/ Business/US EN/Business+ Product+and+Services/RFID/RFID+Reader+Antennas/AN720_US -EN

[16]. C.-Y.-D. Sim and C.-J. Chi, "A slot loaded circularly polarized patch antenna for UHF RFID reader," IEEE Trans. Antennas Propag., vol. 60, no. 10, pp. 4516–4521, Oct.2012